Agriculture, climate disasters and the law

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16. Agriculture, climate disasters, and the law*

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INTRODUCTION

Agriculture depends on a stable climate. Crops need fertile soil, sufficient water, and temperatures that remain within a certain (plant-specific) bandwidth. Livestock needs healthy grazing land, sufficient water, and livable temperatures. The climate needs to be predictable, so that farmers can plan their activities with the aim to secure the best possible harvest. Such stable conditions only occurred after the previous major climate change that took place on Earth and which marked the end of the last ice age, around 12,000 years ago. Around that time, man began to live in settlements and started to grow his own food through agriculture. The major climate change that we are witnessing in the 21st century, this time man made, severely threatens the necessary climatic equilibrium, hence threatening food security.

This chapter will first briefly summarize the nature of climate disasters that are and will be hitting the agricultural sector, relying mainly on the Intergovernmental Panel on Climate Change's (IPCC) 5th Assessment Report. Then, following the disaster cycle, the chapter discusses: how disaster risks for agriculture can be prevented or mitigated; what emergency response needs to be prepared; and how compensation and rebuilding should be organized after disaster has struck.[1] The aim of this chapter is to find and analyze the main issues on which law and policymakers at the international and at the domestic level should focus on when developing a legal framework that is sufficiently equipped to deal with climate disasters that affect agriculture.

CLIMATE DISASTERS IN AGRICULTURE AND FOOD SECURITY

Given the dependence of agriculture on weather and climate, it does not come as a surprise that the agricultural sector is and will be hit hard by climate change impacts. The impacts are diverse and potentially disastrous for global food security. The latest IPCC report on the impacts on agriculture and food security, from 2014, gives a chilling image of what is expected

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[1] Following the various stages of the disaster cycle as used by DANIEL A. FARBER, *Climate Change and Disaster Law*, in THE OXFORD HANDBOOK OF INTERNATIONAL CLIMATE CHANGE LAW 588–607 (Kevin R. Gray, Richard Tarasofsky, & Cinnamon Carlarne eds., 2016). Other authors make different distinctions. Lyster, for example, refers to four stages: prevention, management, risk transfer post disaster, and post-disaster reconstruction, see Rosemary Lyster, *A Fossil Fuel-Funded Climate Disaster Response Fund under the Warsaw International Mechanism for Loss and Damage Associated with Climate Change Impacts*, 4 TRANSNATNL ENVT'L L. 125, 130 (2015).

to happen and, in fact, is already happening across the world.[2] Water shortages in droughts and heat waves have a negative impact on crops as well as livestock.[3] A surplus of water with excessive precipitation, floods and inundation, and increased and changing occurrence of pests, weeds, and diseases,[4] are but a few examples of the other impacts of climate change that negatively affect agriculture. Extreme weather events, generally, hit rural areas hard with a profound negative impact on rural communities and food production. The IPCC refers to the 2010 Pakistan floods as an example where it was found that 88 percent of the affected households reported income losses of up to 50 percent, with significantly higher rates in rural than urban areas, and to the 2010 Russian heat wave and subsequent export ban, which contributed to the more than doubling of global wheat prices by the end of the year.[5]

When describing climate change impacts on agriculture, usually a distinction is made between gradual worsening of climatic conditions (slow-onset disasters) and natural disasters (sudden-onset disasters). Slow-onset disasters are, for instance, a gradual decline of crop yield caused by climate change, which is expected to reach 5 percent in 2030 and 30 percent in 2080 globally, with the biggest impacts happening in Sub-Saharan Africa and South Asia.[6] Ocean warming, acidification, and changes in ocean salinity and precipitation lead to changes in fish metabolic rates, persistence and patterns of occurrence of harmful algal blooms, and chemical contamination in fish and shellfish at coastal fish farms.[7] Generally, gradual climatic changes affect crop production, plant health, animal production and animal health, fisheries, aquaculture, food trade, food and feed manufacturing, processing and handling, and consumer behavior.[8] Natural hazards affecting agriculture are heat waves (and associated wildfires), droughts, river floods,[9] mudslides, heavy precipitation, tropical storms,[10] and for coastal regions salinity and salt water intrusion, and coastal erosion.[11] These natural hazards have various negative, food safety-related impacts on crops, animals, and food consumers, such as:[12]

[2] John R. Porter et al., *Food Security and Food Production Systems*, in CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY. PART A: GLOBAL AND SECTORAL ASPECTS. CONTRIBUTION OF WORKING GROUP II TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 485–533 (Christopher B. Field et al., eds., 2014) [hereinafter IPCC WGII AR5 Part A]. At its 43rd Session (Nairobi, Kenya, April 11–13, 2016), the IPCC decided to prepare a special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. This report is due to come out in 2019, see http://ipcc.ch/report/sr2/.

[3] For example: high temperatures tend to reduce animal feeding and growth rates, milk yields will be reduced and mortality increased because of heat stress, etc., Porter et al., *supra* note 2, at 508.

[4] *Id.* at 506–07.

[5] *Id.* at 503.

[6] STEPHANE HALLEGATTE ET AL., SHOCK WAVES. MANAGING THE IMPACTS OF CLIMATE CHANGE ON POVERTY 4 (World Bank 2016).

[7] M.C. Tirado et al., *Climate Change and Food Safety: A Review*, 43 FOOD RES. INT'L 1745, 1746 (2010).

[8] *Id.*

[9] Hallegatte et al., *supra* note 6, at 6.

[10] Hans J.P. Marvin et al., *Proactive Systems for Early Warning of Potential Impacts of Natural Disasters on Food Safety: Climate-Change-Induced Extreme Events as Case in Point*, 34 FOOD CONTROL 444, 446 (2013).

[11] Purnamita Dasgupta et al., *Rural Areas*, in IPCC WGII AR5 Part A, *supra* note 2.

[12] Tirado et al., *supra* note 7 at 1745–46.

1. changes in persistence and patterns of occurrence of bacteria, viruses, parasites and fungi, and associated food-borne diseases, changes in emergence, distribution and intensity of plant and animal diseases and pest infestations;
2. contamination of soil, agricultural lands, water and food, and animal feed with pathogens, chemicals, and other hazardous substances, originating from sewage or waste dumps.

Against this background of increasing climate change impacts on agriculture, both through slow- and sudden-onset disasters, it is particularly worrying that food demand is growing, and will continue to grow, over the next few decades until 2050. It has been calculated that global food production needs to increase by 40 percent to meet growing demand, mainly because of population growth (the world's population will grow from 7 billion today to 9 billion in 2050) and because of a rise in global calorie intake by 60 percent due to greater affluence, particularly in countries like China and India.[13] The IPCC concludes that "each additional decade of climate change is expected to reduce mean yields by roughly 1%, which is a small but nontrivial fraction of the anticipated roughly 14% increase in productivity per decade needed to keep pace with demand."[14]

All of these factors will lead to an increase of food prices across the globe, as the food market is a global market. According to the IPCC, "it is very likely that changes in temperature and precipitation . . . will lead to increased food prices by 2050, with estimated increases ranging from 3 to 84%."[15] It is especially this rise in food prices that is thought to have severe impacts on human security as described in the IPCC AR5:[16]

> Food prices and food-price shocks have significant impacts on human security. They do so through reduced access to, and production of, food that affects both consumers and food producers. It is well established that food security is determined by a range of interacting factors including poverty, water availability, food policy agreements and regulations, and the demand for productive land for alternative uses. It is also established that many of these factors are themselves sensitive to climate variability and climate change.

A World Bank report adds that losses in the agricultural sector and spikes in food prices can push vulnerable consumers into poverty, as poor people spend a large part of their budget on food.[17] Nonagricultural households and urban residents are the most vulnerable.[18] The 2008 food price spike caused around 100 million people to fall into poverty,[19] and the 2010–2011 food price spike has been estimated to have pushed 44 million people below the basic needs poverty line across 28 countries.[20] The IPCC notes that food prices and food availability also affect sociopolitical stability and in the case of

[13] BRUCE CAMPBELL ET AL., AGRICULTURE AND CLIMATE CHANGE: A SCOPING REPORT 1 (Meridian Institute, 2011).

[14] Porter et al., *supra* note 2, at 505.

[15] *Id.* at 512.

[16] W. Neil Adger et al., *Human security*, in IPCC WGII AR5 Part A, *supra* note 2.

[17] Hallegatte et al., *supra* note 6, at 5.

[18] *Id.*

[19] *Id.*

[20] Adger et al., *supra* note 16, at 763.

the 2008–2009 and 2010–2011 food price spikes have been associated with food riots.[21] It concludes: "There is robust evidence that food security affects basic-needs elements of human security and, in some circumstances, is associated with political stability and climate stresses."[22] Although causal relations are not linear, it is clear that there is a strong relationship between climate disasters, such as droughts, and situations of acute insecurity, such as famine, conflict, and sociopolitical instability.[23]

Developing countries are particularly vulnerable to climate disasters that hit the agricultural sector. In a paper published by the World Meteorological Organization, Sivakumar shows that the poorer the country, the larger the share of agriculture in terms of gross domestic product, total employment, and exports. Rural poverty, thus, is one of the key factors that shapes the risk to natural disasters: Low agricultural productivity combined with extreme poverty makes the populations living in least developed countries the most vulnerable to natural disasters.[24] Sivakumar adds that climate disasters in poor countries lead to disruption of economic activity and to the diversion of government funds to prepare for and recover from natural disasters away from the rural sector.[25] Within poor countries, it is the poorest that are most at risk, as the poorest in the rural areas occupy the most marginal lands that are most prone to natural disasters.[26]

Severe impacts, however, will not only hit poor countries. Developed countries with a large agricultural sector will be affected too. The Australian farming sector, for instance, provides 93 percent of domestic food supply and is an important exporter of food products. Some of the impacts highlighted by the IPCC for the Australian agriculture sector are:

1. a reduction in gross value of the beef, sheep and wool sector;
2. decline of dairy productivity;
3. highly uncertain impacts on cropping, with wheat and rice yields increasing or decreasing depending on regional differences in expected rainfall;
4. reduced wine quality;
5. highly uncertain impacts on weeds, pests, and diseases.[27]

[21] *Id.*

[22] *Id.*

[23] *Id.* at 762. It should be noted that famine may also intentionally be created or manipulated by government, see David Marcus, *Famine Crimes in International Law*, 97 AJIL 245–81 (2003); Alessandro Tonutti, Famine Crisis and International Crimes (International Law and Disasters Working Paper 02, 2014), http://disasterlaw.sssup.it/?page_id=314.

[24] M.V.K. Sivakumar, *Natural Disasters and Their Mitigation for Sustainable Agricultural Development*, in Management of Natural and Environmental Resources for Sustainable Agricultural Development: Proceedings of a World Meteorological Organization Workshop, 175 (R. Stefanski & P. Pasteris eds., 2006) http://www.wamis.org/agm/pubs/agm10/WMO-TD1428.pdf.

[25] *Id.*

[26] *Id.* at 176.

[27] Andy Reisinger & Roger L. Kitching et al., *Australasia*, in Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Vicente R. Barros et al. eds., 2014) at 1396–99.

Consumers in developed countries are expected to face food safety issues caused by climat change. A study into food safety hazards in the Dutch dairy production chain, caused b increasing variable and extreme weather conditions such as increasing temperatures an excessive rainfall, found numerous critical factors. Loss of feed (both raw materials an pasture) and feed storage, for example, as well as animal health problems are thought t be the most important critical factors that affect the occurrence of food safety hazarc due to climate change.[28] A European study found that consumers in Europe should expec mycotoxins formed on plant products in the field or during storage, residues of pesticides i plant products affected by changes in pest pressure, trace elements and/or heavy metals i plant products depending on changes in their abundance and availability in soils, polycycli aromatic hydrocarbons in foods following changes in long-range atmospheric transpor and deposition into the environment, marine biotoxins in seafood following productio of phycotoxins by harmful algal blooms; and the presence of pathogenic bacteria in food following more frequent extreme weather conditions, such as flooding and heat waves.[29]

Rural communities in developed countries are particularly vulnerable to climate chang impacts for several reasons, such as the substantially higher average age compared to urba areas. The IPCC refers to the social impact of the prolonged drought in Australia during th early 2000s, which led to "farm closures, increased poverty, increased off-farm work, anc hence, involuntary separation of families, increased social isolation, rising stress and assoc ated health impacts, including suicide (especially of male farmers), accelerated rural depopu lation, and closure of key services."[30] Generally, the IPCC concludes that with ineffectiv global mitigation, Australia will face an increase in flood risk, water scarcity, heat waves, an wildfires, coastal damage from sea level rise, and loss of agriculture production from sever drying, to such an extent that the associated impacts would so severely challenge adaptiv capacity, including transformational changes, that they constitute important risks.[31]

DISASTER MITIGATION IN AGRICULTURE

Of the three phases of the disaster cycle discussed here (disaster mitigation, disaste response, and compensation and rebuilding), the first is by far the most important one Not just because of the simple fact that "an ounce of prevention is worth a pound o cure,"[32] but also because of the nature of climate disasters. Adler rightfully observes tha "drought and other disaster response policies that might be appropriate for occasiona and difficult-to-foresee events may no longer be appropriate for conditions that will nov occur with increasing frequency due to climate disruption."[33]

[28] M. van der Spiegel, H.J. van der Fels-Klerx & H.J.P. Marvin, *Effects of Climate Change o Food Safety Hazards in the Dairy Production Chain*, 46 Food Res. Int'l 201–08 (2012).

[29] M. Miraglia et al., *Climate Change and Food Safety: An Emerging Issue with Special Focus o Europe*, 47 Food & Chemical Toxicology 1009–21 (2009).

[30] Reisinger et al., *supra* note 27, at 1398.

[31] *Id.* at 1412.

[32] Farber, *supra* note 1, at 597.

[33] Robert W. Adler, *Balancing Compassion and Risk in Climate Adaptation: U.S. Wate Drought, and Agricultural Law*, 64 Fla L. Rev. 201, 265 (2012).

As can be seen from the above description of climate change impacts on agriculture, climate disaster policy and law with a focus on this sector cannot just focus on extreme weather events such as large storms, floods, and massive prolonged droughts. Unspectacular climatic anomalies can cause major damage to crops and heavily affect food security.[34] As discussed above, agriculture is partly affected by individual extreme weather events, but for a large part also by slow-onset disasters. The low visibility of such anomalies or slow-onset disasters for the wider public and policymakers bears the risk that impacts are underestimated and not addressed within the framework of disaster management. Farber's observation that there is an unwillingness to imagine the full scope of potential climate change risks is a recurrent problem is especially true for the agricultural sector.[35] That is why it is important to focus disaster mitigation in agriculture not just on the highly visible extreme weather events. Instead, a broader, more holistic approach should be pursued based upon the precautionary principle,[36] and through collaboration between various levels of governance, as promoted by the Sendai Framework for Disaster Risk Reduction 2015–2030.[37] Such broader approach to disaster mitigation should focus on the following elements: the adoption of climate-smart or sustainable farming practices and technologies, the use of early warning systems, and improved use of climate and weather forecasts.

I. Climate-smart Agriculture

Disaster mitigation for agriculture starts with the adoption of sustainable farming practices and of adaptation measures in this sector,[38] often referred to as climate-smart practices and technologies. Climate-smart agriculture is an approach to developing the technical, policy, and investment conditions to achieve sustainable agricultural development for food security under climate change, and is composed of three main pillars: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing or removing greenhouse gas emissions.[39] As such, climate-smart agriculture fits very well as a measure aimed at achieving Sustainable Development Goal 2.[40]

[34] Sivakumar, *supra* note 24, at 175–76.

[35] Farber, *supra* note 1, at 595.

[36] *Id.* at 597.

[37] UNGA, Sendai Framework for Disaster Risk Reduction 2015–2030, A/RES/69/283 (2015). The Sendai Framework (under No. 28) acknowledges the importance of fostering collaboration across global and regional mechanisms and institutions for the implementation and coherence of instruments and tools relevant to disaster risk reduction in the areas of climate change, agriculture, and food security.

[38] Van Niekerk shows the importance of merging the climate change adaptation and the disaster risk reduction agendas, Dewald van Niekerk, *Climate Change Adaptation and Disaster Law*, in Research Handbook on Climate Change Adaptation Law 142–70 (Jonathan Verschuuren ed., 2013).

[39] FAO, Climate Smart Agriculture Sourcebook ix (2013).

[40] UNGA, Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1 (2015). SDG Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

It is important that these three pillars are always considered in an integrated Research shows, for instance, that mitigation policies using a global carbon price v does not account for food production implications will hurt crop and livestock pr tion.[41] The loss of production that may occur in this way may even be larger tha loss through climate change itself. Modeling shows that large-scale afforestation substantial carbon sequestration up to 2100 will lead to food price increases of a 80 percent in 2050 and 400 percent by 2100.[42] To avoid such negative impacts, ca pricing policies should be developed thoughtfully,[43] and aim for adaptation and production co-benefits.[44]

Increased resilience can be a side-effect of carbon-offset projects in agriculture. ticularly of those projects aimed at increased carbon sequestration in soils and pla vegetation on agricultural lands, as these lead to more fertile soils and better moi retention and thus to increased production, better water management, and reduced lizer use.[45] A recent literature review found that increasing soil carbon can have prof effects on soil quality and agro-ecosystem productivity. Soil carbon plays an impo role in maintaining soil structure, improving soil-water retention, fostering healthy microbial communities, and providing fertility for crops.[46] Also, soil-carbon project often part of the introduction of wider regenerative practices that focus on soils, v and biodiversity.[47] Research also found that farmers practicing sustainable agricultur better able to cope with extreme weather events than conventional farmers.[48] Gon refers to surveys following Hurricane Mitch in Central America, which showed tha land of sustainable farmers had 40 percent more topsoil, greater levels of moisture, vegetation, and less soil erosion than the lands of conventional farmers.[49] UN-led n

[41] Hallegatte et al., *supra* note 6, at 56.

[42] Ulrich Kreidenweis et al., *Afforestation to Mitigate Climate Change: Impacts on Food I under Consideration of Albedo Effects*, 11 Envtl Res. Letters 1 (2016).

[43] *Id.* at 9. Kreidenweis et al. make a number of recommendations: Afforestation shou restricted to the tropics so as to achieve the highest possible sequestration with the lowest in on food production, agricultural trade should be liberalized so as to dampen price effects in cal regions, the carbon pricing mechanism should allow for monetary flows to go to the tr regions so as to compensate for some of the disadvantages for these regions, to avoid that lished forests are cut down again, and to develop technologies and practices aimed at yield inc

[44] Jonathan Verschuuren, *Towards a Regulatory Design for Reducing Emissions from Agricu Lessons from Australia's Carbon Farming Initiative*, 7 Climate L. 1, 50 (2017).

[45] *Id.* at 11, 42 and 44.

[46] Daniel Kane, Carbon Sequestration Potential on Agricultural Lands: A Revie Current Science and Available Practices 18 (National Sustainable Agriculture Coalition, 2 See also, among many others, Rattan Lal, *Societal Value of Soil Carbon*, 69(6) J. Soil & W Conservation 186A–92A (2014); F. Alliaume et al., *Changes in Soil Quality and Plant Ava Water Capacity Following Systems Re-design on Commercial Vegetable Farms*, 46 Eur. J. Agro 10–19 (2013).

[47] In Australia, for example, there is growing support for such programs as 'soils for life 'healthy soils.' Case studies show remarkable results of reduced carbon emissions, better gr conditions, more water availability, and more biodiversity, see http://www.soilsforlife.org.a http://www.healthysoils.com.au.

[48] Carmen G. Gonzalez, *Climate Change, Food Security, and Agrobiodiversity: Toward a Resilient, and Sustainable Food System*, 22 Fordham Envtl L. Rev. 493, 514 (2011).

[49] *Id.* at 514–15.

projects in drought-prone areas in the Horn of Africa showed that small-scale adaptation measures aimed at improving the sustainability of agro-ecosystems led to increased food production and decreased use of chemical fertilizer and pesticides, saving farmers money, reducing pollution, and allowing depleted soils to recover.[50]

Improving soil quality is an important measure that farmers can take to mitigate climate disaster risks, but not the only measure. Farmers can also change the sowing according to expected seasonal weather, and they can introduce new crops that are better suited to being cultivated under the changing climatic and weather conditions, for instance switching to faster ripening varieties so as to move from single to double cropping, thus making use of the longer potential crop-growing season,[51] or to drought resistant crops.[52] New drip-irrigation technologies allow for increased food production with drastically decreased water use, and the adoption of water spreading, harvesting, and storage facilities allow for a better use of rainfall and the development of rain-fed agriculture.[53]

Most countries, around the globe, do not have comprehensive and effective legal instruments in place that stimulate farmers to adopt climate-smart practices and technologies.[54] To make the agricultural sector more resilient to climate disasters (as well as reducing emissions from agriculture, and increasing food production), it is essential that law- and policymakers around the world rapidly start developing policies and laws so that climate-smart agricultural practices are commonplace soon.[55] Financial instruments such as subsidies or offset mechanisms under carbon pricing programs can be used to achieve this goal.[56] Another important element of laws and policies aimed at climate-smart agriculture is the integration of agricultural management and water management.[57] Domestic and local water laws have to enable investments in water development and distribution systems.[58] In most countries, this requires significant adaptation in the laws and institutions governing water resources. Adler has shown that in areas with declining water supplies, water law will have to adapt to allocate water to the most important uses, and reallocate available water supplies where needed, potentially disrupting some economic

[50] Richard Munang & Johnson N. Nkem, *Using Small-Scale Adaptation Actions to Address the Food Crisis in the Horn of Africa: Going beyond Food Aid and Cash Transfers*, 3 SUSTAINABILITY 1510, 1514–15 (2011).

[51] Sivakumar, *supra* note 24, at 185.

[52] There is big ongoing debate as to whether plant species that have been genetically engineered to be drought resistant are the best solution for farmers in drought-prone areas. For a recent overview of the debate, see for example Anne Saab, *Climate-Resilient Crops and International Climate Change Adaptation Law*, 29 LEIDEN J. INTERNATIONAL LAW 503–28 (2016).

[53] Sivakumar, *supra* note 24, at 185.

[54] Verschuuren, *supra* note 44, at 6–10.

[55] *Id.* at 51.

[56] Jonathan Verschuuren, *Stimulating Climate Smart Agriculture within the Boundaries of International Trade Law*, 10 CARBON CLIMATE L. REV. 177, 178–80 (2016).

[57] Pete Falloon & Richard Betts, *Climate Impacts on European Agriculture and Water Management in the Context of Adaptation and Mitigation — The Importance of an Integrated Approach*, 408 SCI. OF THE TOTAL ENV'T 5667 (2010).

[58] Robert W. Adler, *Climate Change and Water Law in Agriculture*, in RESEARCH HANDBOOK ON CLIMATE CHANGE AND AGRICULTURAL LAW 103, 112 (Mary Jane Angelo & Anél Du Plessis eds., 2017).

activities.[59] Expensive investments in water infrastructure are required to accomm water efficiency and reuse.[60] Market-based instruments, such as the tradable wate that exist in Australia,[61] seem helpful in generating the funds needed to meet the c these investments.

II. Early Warning Systems

The availability of a well-functioning early warning system is a prerequisite for d preparedness, to help farmers to manage the hazards and avoid these turnin disasters.[62] Early warning systems aimed at flood forecasts, at El Niño forecas at tropical cyclone tracks already have proved valuable instruments to prevent cas and economic loss.[63]

Early warning systems that specifically focus on food security exist as well. A study on early warning systems for food security distinguished between three ty early warning systems that can be applied.[64] First, there are various internet-sc software tools that collect information related to food safety hazards such as pe contamination, and indirect threats for agriculture such as floods, droughts, and outbreak. By monitoring news feeds and websites on a real-time basis, such s report on food and feed hazards caused by the outbreak of diseases and can se alerts to farmers.[65] Proactive predicting systems are the second category of early w systems, albeit mostly in early stages of development. There are systems that p the occurrence of mycotoxins in grain, which are thought to be helpful in plant c management under climate change,[66] and there are algal blooms warning syste predict the occurrence of harmful algal blooms and the species involved.[67] The category of early warning systems are so-called "holistic" systems that also take h into consideration that originate in or are influenced by events and develop outside the food production chain. Holistic systems seem very well suited for p ing climate change impacts on food production by linking weather trends (incl weather extremes) with information on crop and animal diseases/pests, and ch and microbiological food safety hazards.[68] These systems, however, are in a very stage of development.[69] International collaboration and fundraising seems requi speed up the development and implementation of early warning systems for agric climate disasters.

[59] *Id.* at 132.

[60] *Id.* at 133.

[61] Cameron Holley & Darren Sinclair, *Governing Water Markets: Achievements, Limi and the Need for Regulatory Reform*, 33 ENVTL & PLAN. L. J. 275, 301 (2016).

[62] Sivakumar, *supra* note 24, at 182.

[63] *Id.* at 183–84. Hallegatte et al., *supra* note 6, at 103.

[64] Marvin et al., *supra* note 10, at 449.

[65] *Id.* at 450.

[66] *Id.*

[67] *Id.* at 451.

[68] *Id.* at 452.

[69] *Id.* at 454.

III. Climate and Weather Information and Forecasts

Related to the previous climate disaster mitigation strategy is the use of climate and weather forecasts. Such forecasts are relevant both for short-term and long-term decision-making by farmers. Timely information on extreme weather events allows farmers to take precautionary measures to protect crops and livestock. Seasonal forecasts allow farmers to decide about seasonal crop planning and to forecast expected yield.[70] According to Sivakumar, however, more work needs to be done to make the forecasts more useful for farmers. Sivakumar argues for greater participation of farmers in the development of forecasting systems, so that forecasters are more aware of the influence of weather and climate parameters on sustainable agricultural production.[71]

DISASTER RESPONSE IN AGRICULTURE

The description above of climate disasters that affect agriculture shows that there are many different types of disasters that are relevant for this sector. The disaster response that is needed after a disaster has taken place, therefore, may vary greatly. As discussed, the ultimate and most devastating effect of climate disasters impacting agriculture is famine. In developing countries local communities depend on the food that farmers grow in their own region. This means that the first humanitarian response to climate disasters hitting agriculture in developing countries will be the supply of food aid to the general population.[72]

Humanitarian assistance by the international community for the agricultural sector following disasters and crises has been limited. According to the Food and Agriculture Organization (FAO), between 2003 and 2013, about 3.4 percent of all humanitarian assistance was directed to the agriculture sector, with an average of around US$374 million annually.[73] The average annual crop and livestock production losses in developing countries, however, were much larger: An analysis of 140 disasters triggered by natural hazards found annual costs of crop and livestock losses to be US$7 billion per year over the same period.[74]

The role of international law in responding to disasters is often criticized. Hoffman's words describing the "yawning gap" between international humanitarian law's comprehensive and well-developed protection of victims of armed conflict on the one hand, and the absence of international legal standards, procedures, rights, and duties aimed at protecting victims of other disasters,[75] are now a standard starting point for any

[70] Sivakumar, *supra* note 24, at 181.

[71] *Id.* at 180.

[72] For instance under the World Food Programme. The WFP's website contains much information on climate disasters, related food and nutrition crises, and what response is needed, see http://www.wfp.org/climate-change.

[73] FAO, THE IMPACT OF DISASTERS ON AGRICULTURE AND FOOD SECURITY 51 (2015).

[74] *Id.*

[75] MICHAEL HOFFMAN, *Towards an International Disaster Response Law*, in WORLD DISASTERS REPORT 2000 145 (P. Walker, J. Walker eds., 2000).

publication on international disaster response law.[76] The lack of a comprehensiv framework on international disaster response is illustrated by a lack of coordi failure to empower local authorities and communities, and, generally, unfam of domestic emergency managers with available international instruments in a of major international disaster response operations in the past few years.[77] W expected increase in the number and size of disasters under climate change o next few decades, much remains to be done to improve our ability to effectively r to climate disasters.[78] The adoption of the "Draft articles on the protection of p in the event of disasters" by the International Law Commission is a first step t the establishment of a comprehensive legal framework for international coopera disaster response.[79]

There is one international convention that is particularly relevant to addres security when a climate disaster has struck: the Food Assistance Convention.[80] convention lays down a set of principles and best practices for effective and e food assistance for the most vulnerable people that does not harm local mark the long-term resilience, self-reliance, and food security of the community.[81] One principles is also aimed at acknowledging that local authorities and stakeholders play a primary role in the organization, coordination, and implementation of th assistance program.[82] In addition, General Comment No. 12 on the right to fo guaranteed under Article 11 of the International Covenant on Economic, Soci Cultural Rights,[83] specifically states that states have the obligation to fulfill the r food of victims of natural or other disasters.[84] The General Comment also stat victims of natural disasters and people living in disaster-prone areas may need attention and sometimes priority consideration with respect to accessibility of States should, therefore, cooperate with other states and relevant NGOs to meet th calorie needs of the communities hit by a climate disaster. This means that auth

[76] Farber, *supra* note 1, at 597. See in more detail also Kirsten Nakjavani Bookmiller, *'the Yawning Gap'? International Disaster Response at Fifteen*, in RESEARCH HANDBO DISASTERS AND INTERNATIONAL LAW 251–71 (Susan C. Breau & Katja L.H. Samuel eds. [hereinafter Breau, RESEARCH HANDBOOK ON DISASTERS].

[77] Farber, *supra* note 1, at 598. Nakjavani Bookmiller, *supra* note 76, at 62.

[78] Stephens notes that at best, international environmental law functioned quite responding to localized environmental disasters. Climate change, however, poses threats entirely different magnitude. Tim Stephens, *Disasters, International Environmental Law Anthropocene*, in Breau, RESEARCH HANDBOOK ON DISASTERS, *supra* note 76.

[79] ILC, DRAFT ARTICLES ON THE PROTECTION OF PERSONS IN THE EVENT OF DISASTERS adopted by the International Law Commission at its sixty-eighth session, in 2016, and sub to the General Assembly as a part of the Commission's report covering the work of that (A/71/10), para. 48.

[80] Food Assistance Convention, April 25, 2012, 52 I.L.M. 354 (2013).

[81] Art. 2.

[82] Art. 2(b)(viii).

[83] International Covenant on Economic, Social and Cultural Rights, 16 December I I.L.M. 360 (1967).

[84] CESCR General Comment No. 12: The Right to Adequate Food (Art. 11), 12 May E/C.12/1999/5 (1999), paras 6 and 15.

[85] *Id.* at para 13.

involved should ensure that domestic administrative requirements, for instance those related to the import of food products, do not unnecessarily delay the delivery of food to those in need.[86]

A major issue in disaster response policy and law aimed at agriculture is the timing of the response. As Adler observes: "[d]eclaring drought (and providing relief) too readily can discourage prevention and risk reduction, while declaring drought too late can result in significant hardship and secondary impacts."[87] Domestic disaster response law and policies should, therefore, provide relief only to those who take appropriate measures to reduce vulnerability, such as switching to low-water-demand crops in drought-prone regions or improving irrigation technologies.[88]

COMPENSATION AND REBUILDING

Getting the farmer back into business as quickly as possible, so that food production is restored, is of the utmost importance for providing food security, especially in developing countries. Telesetsky argues that the phase after a disaster is an extremely difficult phase for the farmers involved, yet essential for the future resilience of the community.[89] Because of a lack of resources, farmers in developing countries often tend to invest in low-risk crops with low return and communities choose to reduce food consumption, both of which negatively impact the resilience of the farms and the communities and do not prepare for the next disaster.[90]

Financial aid is usually needed so that farmers in developing countries can clean up and prepare the land for agricultural activities and buy new seeds, new machines, and new livestock. At the international level, organizations such as the World Bank, the International Fund for Agricultural Development, and the Special Climate Change Fund under the United Nations Framework Convention on Climate Change (UNFCCC), put much effort into providing such financial aid. It is now well understood that farmers and communities should undertake investments with long-term benefits, so that the next climate disaster has less impact.[91] The compensation and rebuilding phase, therefore, is closely linked to the disaster mitigation phase.

The situation is different for farmers in developed countries. Here, the right to food usually is not at stake, as local communities do not solely depend on locally produced food. In developed countries, one could raise the question why compensation for damage to agriculture caused by climate change is needed. It could be argued that it is not up to the legal system to compensate for accident costs and that it is unfair to give preferential treatment to victims of catastrophes compared to other victims, those hit by an individual

[86] Anastasia Telesetsky, *An Evolving Role for Law and Policy in Addressing Food Security Before, During and After a Disaster*, in Breau, Research Handbook on Disasters, *supra* note 76.

[87] Adler, *supra* note 33, at 265.

[88] *Id.* at 265–66.

[89] Telesetsky, *supra* note 86, at 264–65.

[90] *Id.* at 265.

[91] For an overview of the various initiatives at the international level, see *id.* at 265–69.

accident.[92] Usually, it is the scale of loss and the impact on welfare and society tl referred to as the main reason why governments should make sure that some for compensation is in place, and there usually is a strong political desire to compe victims of catastrophes.[93]

A range of methods is explored for their suitability to compensate for the loss ca by climate change. I will discuss three important types of compensation that seem par larly relevant for the agricultural sector: various types of more or less private insur (including reinsurance), various forms of direct government payment, and various fi of a compensation fund.[94]

First and foremost, there are various products offered to farmers by the fi cial and insurance markets aimed at sharing and transferring risks, ranging different types of private insurance to weather derivatives and catastrophe bon The latter are financial products of the capital market that take over insurance ris Although private insurance has its limitations in the case of climate disasters, insurance products are being developed, such as the "Broad Weather Insurance Pol which was developed by agricultural insurance companies together with agribusi organizations and the government in the Netherlands to offer farmers insur against climate change-related crop damage.[97] This policy covers financial loss ca by natural disasters, such as extreme rainfall, extreme drought, erosion, severe w storms, hailstorms, and fires (caused by lightning). This insurance does not cove damages, but instead requires farmers to bear 30 percent of the loss. The governr has a subsidy scheme in place to provide financial assistance to individual farme pay for the premium.

This Dutch climate change damage insurance policy for famers is an example of f party insurance coverage which was designed to conquer the limitations of first-p insurance as a mechanism to deal with climate disasters, in particular the low-probab high-loss character of climate disasters.[98] Reinsurance is another mechanism to deal this limitation of first-party insurance.[99] Managing climate disaster risks is a gro market for reinsurance businesses.[100] Reinsurance firms are even starting to operat developing countries in Africa, where micro-insurance policies have been developec

[92] Michael Faure, *Climate Change Adaptation and Compensation*, in Research Handb on Climate Change Adaptation Law 110, 112–13 (Jonathan Verschuuren ed., 2013).

[93] *Id.* at 113. Lyster, *supra* note 1, at 130.

[94] I do not discuss direct civil liability as an option as it is unlikely that farmers will be ab successfully sue companies or governments that can be held liable for the types of climate cha related damage that farmers face; see also Lyster, *supra* note 1, at 139–40.

[95] FAO, Climate Change Adaptation and Mitigation in the Food and Agricul Sector 10 (2008).

[96] Lyster, *supra* note 1, at 138–39.

[97] W.J. Wouter Botzen, Managing Extreme Climate Change Risks through Insura 57 (2012). For an up-to-date description of the cover of the current policy, see agricultural in ance company 'AgriVer' website, http://www.agriver.nl/gewassen-te-velde.html (in Dutch).

[98] Faure, *supra* note 92, at 121.

[99] *Id.* at 134.

[100] Such as Swiss Re, see http://www.swissre.com/rethinking/climate_and_natural_disaster_ (last visited May 16, 2017).

farmers to cover for loss of crops due to drought, storms, pests, and diseases.[101] Despite growing interest among poor farmers, insurance penetration of agriculture in Africa is on average only 1 percent.[102] Developing reinsurance opportunities with the participation of banks, governments, and NGOs may indeed help to increase the number of insured farmers in developing countries, although it is as yet unclear whether micro-insurance initiatives in developing countries can really be scaled up to such an extent that the majority of farmers are covered for climate change-related damage.[103]

It is clear from these examples that private markets alone cannot provide the funding that is needed to develop and operate insurance products for farmers to protect them from financial losses caused by climate disasters. Some form of government intervention is probably always needed to make climate disaster insurance for farmers a success.[104]

Another option to cover farmers' losses caused by climate disasters is through direct government payments. The main difference with insurance-type instruments is that farmers do not pay a premium in advance, but simply rely on the government to act in case disaster strikes. In the previous section, on disaster response, it was noted that it is important to balance the disaster response against disaster risk reduction. This is equally true for government-sponsored compensation. Adler, referring to the US Disaster Relief Act, states that disaster relief in the form of compensation is often controversial as it might encourage farmers to not adapt to the changing climate, but, instead, to engage in riskier agricultural practices because of the promise of public relief.[105] Hence, in the compensation and rebuilding phase, attention needs to be focused as much on disaster mitigation as on the rebuilding.[106] According to Faure, any compensation policy should, therefore, always keep the incentives for preventing damage intact.[107] In agriculture, this can be done, for instance, by only compensating farmers who plan ahead for the next drought (saving water for later during wet periods by reduced water use and increased storage).[108] Domestic disaster relief legislation could also limit compensation to be paid only to those farmers who are insured against damage caused by disasters, such as floods, in which case government funds are used to compensate these farmers for those losses that were not covered by the insurance. The latter is the case in the Netherlands, where the Disaster Compensation Act provides that farmers cannot apply for compensation for damage that is insurable.[109] A special piece of legislation that was enacted to compensate

[101] The World Bank's Global Index Insurance Facility, for example, stimulated the emergence of ACRE Africa (Agriculture and Climate Risk Enterprise Ltd.), operating in Kenya, Rwanda, and Tanzania, see ACRE's website http://acreafrica.com (last visited May 16, 2017).

[102] According to Swiss Re, *Meeting the agricultural challenge in Africa*, available online through http://www.swissre.com/rethinking/food_security/meeting_the_agricultural_challenge_in_africa.html (last visited May 16, 2017).

[103] Lyster, *supra* note 1, at 138.

[104] For a detailed taxonomy of possible government intervention, V. Bruggeman, M. Faure, & T. Heldt, *Insurance Against Catastrophe: Government Stimulation of Insurance Markets for Catastrophic Events*, 23 DUKE ENVTL L. & POL'Y F. 185–241 (2012).

[105] Adler, *supra* note 33, 204.

[106] *Id.* at 220.

[107] Faure, *supra* note 92, at 114.

[108] Adler, *supra* note 33, at 221.

[109] Disaster Compensation Act 1998 (*Wet tegemoetkoming schade bij rampen*), Art. 4(3)(a).

farmers following extreme rainfall in 2002 even states that compensation is only g to farmers who have been insured against damage caused by excessive rainfall for a of five consecutive years.[110]

A third pathway to compensate farmers and to help them rebuild their farming bu is to establish a domestic climate change compensation fund funded by a carbon or an international climate disaster response fund under the UNFCCC, funded by imposed upon the fossil fuel industry and open only to claims by developing count The latter is a proposal that might well be discussed under the Warsaw Interna Mechanism for Loss and Damage associated with Climate Change Impacts in parties to the UNFCCC cooperate to address loss and damage associated with imp climate change, including extreme events and slow-onset events, in developing cou that are particularly vulnerable to the adverse effects of climate change.[113]

CONCLUSION

Agriculture depends on a stable and predictable climate, enabling farmers to plan activities with the aim to secure the best possible harvest. Climate disasters are al impacting on agricultural activities and, thus, on food security. Water shorta droughts and heat waves have a negative impact on crops as well as livestock. Exc precipitation, floods and inundation, and increased and changing occurrence of weeds, and diseases are other examples of climate disasters that have devastating im on food production. Generally, it can be said that extreme weather events hit rural hard with a profound negative impact on rural communities and food production. C basis of a multidisciplinary literature review (disaster, climate, international, huma ian, environmental, and agricultural law, and agricultural and food sciences), this ch has discussed the main issues that international and domestic law and policymakers to focus on when developing a legal framework that is sufficiently equipped to deal agricultural climate disasters. Three stages have been distinguished: the disaster mitig phase, the disaster response phase, and the compensation and rebuilding phase.

Disaster mitigation for agriculture starts with the adoption of sustainable far practices and of adaptation measures in this sector. The adoption and implement of climate-smart practices and technologies across farms around the world has stimulated and facilitated by laws and policies, for instance by introducing fina benefits to farmers who do so, or by integrating water and agricultural laws. Early wa systems aimed at helping farmers to prepare for and manage climate disasters partly International collaboration and fundraising seems required to speed up the develop and implementation of such early warning systems. The same is true for climate

[110] Regulation on Crop Damage Compensation (*Tegemoetkomingsregeling oogstschade 2* Art. 6.

[111] Faure, *supra* note 92, at 126.

[112] Lyster, *supra* note 1, at 146.

[113] Christina Voigt, *Climate Change and Damages*, in THE OXFORD HANDBOOK OF INTERNATI CLIMATE CHANGE LAW 464, 465 (Kevin R. Gray, Richard Tarasofsky, & Cinnamon Carlarne 2016).

weather information and forecasts. Forecasters have to improve the usability of their forecasts for sustainable agricultural production.

In developing countries, local communities are dependent on local agriculture for their food supply. That is why disaster response in the area of agriculture usually concerns food supply. It is generally accepted that states under international law have the obligation to fulfill the right to food of victims of climate disasters. Although a comprehensive international legal framework for disaster relief is sadly lacking, there are various international law instruments in place that set principles and guidelines on how to supply food to those who are in need. The further development of a comprehensive international legal framework for disaster response that also focuses on agriculture and food security is urgently required.

The rebuilding phase is crucial with a view to creating a better, more resilient, agricultural sector, so that it is better suited to deal with the next climate disaster. For developing countries, this can only be done when financial means are provided to farmers to help them invest in climate-smart practices and technologies. Various international financial institutions, for instance those working under the UNFCCC, are committed to providing such financial means. Developed-country farmers can usually apply for domestic disaster compensation. To prevent farmers from continuing to rely on government aid and not make the necessary changes to become more resilient to climate change, it is important that domestic legal instruments in the area of disaster compensation reward the adaptive farmer. Various forms of insurances are increasingly becoming available to insure against agricultural losses due to climate disasters, even in developing countries. This is an important development that needs to be stimulated and facilitated by insurers (as discussed in Chapter 19), banks, governments, and NGOs.

PART IV

PRIVATE LAW AND CLIMA DISASTERS